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WATER RESOURCES STUDY AND PUBLIC HEALTH ASPECTS OF THE DALLAS CREEK PROJECT, COLORADO: STUDY OF POTENTIAL NEEDS AND VALUE OF STORAGE OF WATER FOR QUALITY CONTROL PURPOSES AND THE PUBLIC HEALTH ASPECTS OF THE PROJECT

Public Health Service
Denver, Colorado

October 1963

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WATER RESOURCES STUDY
and
PUBLIC HEALTH ASPECTS
of the
DALLAS CREEK PROJECT, COLORADO

Study of Potential Needs and Value of Storage of Water for Quality Control Purposes and the Public Health Aspects of the Project

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By
U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VIII
Division of Water Supply and Pollution Control
Denver, Colorado

To
U. S. Department of the Interior
Bureau of Reclamation, Region 4

OCTOBER 1963

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General Publications

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PART A - WATER RESOURCES STUDY

I. INTRODUCTION

AUTHORIZATION

In accordance with the memorandum of understanding dated September 28, 1956, between the Bureau of Reclamation, Region 4, Department of the Interior, and the Public Health Service, Department of Health, Education, and Welfare, consideration has been given to the general public health aspects of the Bureau of Reclamation's proposed Dallas Creek Project. Following a meeting of representatives of the two agencies on August 2, 1962, and under terms of a subsequent letter of authorization dated August 14, 1962, the interagency agreement was broadened to recognize Public Health Service reponsibilities set forth in Section 2(b) of the Federal Water Pollution Control Act (Public Law 84-660, as amended by Public Law 87-88).

PURPOSE AND SCOPE

General objectives of this study are to assess the probable effects the proposed project will have on water quality in local streams and reservoirs; to ascertain the benefits or harm resulting from changes in water quality; to assess the suitability of the water for proposed water uses, and to examine the need for regulation of streamflow for the purpose of water quality control. Need for streamflow regulation was studied not only in light of present conditions, but also under anticipated economic development in the Uncompahgre River Basin of the years 1985, 2010, and 2060.

The inclusion of Ironton Park Reservoir in the project was given consideration as significant water quality benefits would accrue to the upper Uncompahgre River and Ridgway Reservoir with Ironton Park Reservoir integrated into the Dallas Creek Project.

The report includes the results of a study of general public health aspects and insect vector control of the project. The insect vector control section, prepared jointly by the Colorado State Department of Public Health and the Communicable Disease Center, Public Health Service, Greeley, Colorado, presents a preliminary evaluation of the insect vector problems that may be associated with the project.

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The cooperation and assistance of many persons and agencies are gratefully acknowledged by the Public Health Service. Particular appreciation is expressed to the following organizations for data and advice furnished by their staff members:

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Branch of River Basin Studies
Denver, Colorado

Colorado State Department of Health
Denver, Colorado

Colorado Department of Game and Fish
Montrose, Colorado

Officials, City of Montrose
Montrose, Colorado

Officials, Town of Ouray
Ouray, Colorado

II. SUMMARY AND CONCLUSIONS

Summary

1. The Dallas Creek Project is a multiple-purpose project of the Bureau of Reclamation. It provides for the interception of flows in the upper Uncompahgre River Basin for supplemental and full service irrigation of lands located primarily in Ouray County, Colorado. Under provision of the 1958 Water Supply Act the Tri-County Water Conservancy District has requested storage for net delivery of 15,000 acre-feet of water in the Ridgway Reservoir for municipal and industrial use.

2. The economy of the study area is basically oriented to agriculture. The population remained essentially constant from 1940 to 1960. However, population trends from 1960 to the present have been upward, primarily in the urban areas.

3. Uncompahgre River water is used primarily for irrigation. Other minor uses include livestock water and limited fishing.

4. A water quality problem exists in the headwaters of the Uncompahgre River as a result of acid mine drainage. The acid causes the dissolution of heavy metals which has adverse effects on the biological life in Red Mountain Creek and downstream to the proposed Ridgway dam site.

5. A water quality problem exists in the lower reaches of the Uncompahgre River as a result of saline irrigation return flows from the Uncompahgre Project.

6. This report presents a preliminary examination of present and future development and water use patterns in the study area. These data, therefore, are intended to serve as a guide to future resource development. As the results of more detailed studies for the area and region become available, modifications may become necessary.

Conclusions

1. The resource base of the study area constitutes a potential for future economic growth.

2. Population in the Dallas Creek study area is expected to increase from 11,250 in 1960 to 23,400 by 1985, and 40,900 by 2060. The recreational impact on the economy is expected to be of major importance throughout the projection period.

3. Surface water supplies must be developed to meet the anticipated water quality and quantity needs if economic development is to occur.

4. Before any recreational use is permitted of Ridgway Reservoir, the City of Ouray, Colorado, must provide secondary treatment of its sewage.

5. Annual average concentrations of total dissolved solids will be reduced about 5% at Colona and increased about 30% at Delta under project operation.

6. The combined flow of the Uncompahgre River above Ridgway, Dallas Creek and diversions from Cow Creek stored in Ridgway Reservoir will provide a raw water supply for municipal purposes meeting the Public Health Service Drinking Water Standards. Calculations indicate that expected concentrations of sulfate, total dissolved solids and hardness would be about 150 mg/l, 300 mg/l, and 200 mg/l, respectively.

7. As heavy metals previously precipitated in the Ridgway Reservoir will go back into solution under anaerobic conditions a two-level municipal water supply intake is recommended at Ridgway Reservoir. This will provide greater flexibility in operation of the intake and permit drawing-off of the better quality water.

8. Consideration should be given by the Bureau of Reclamation to inclusion of Ironton Park Reservoir in the Dallas Creek Project to bring about a reduction in acid mine drainage pollution. In addition to intangible benefits associated with the domestic water supply, this reservoir would provide tangible water quality benefits for fishing and recreation amounting to $49,300 annually.

9. Based upon historical streamflow data, 1939-62, existing water quality could be maintained at Delta under project conditions about 20 percent of the time if monthly flows shown in Column 8 of Table XI are provided. Historical streamflows are insufficient to maintain 1,000 mg/l of total dissolved solids at Delta, without or with the Dallas Creek Project. Existing evidence does not justify the inclusion of water supply storage in Ridgway Reservoir for regulation of streamflow for the purpose of water quality control in the Uncompahgre River, therefore, no monetary value has been assigned.

10. The Bureau of Reclamation should explore possible means to reduce the salt load on the Uncompahgre River resulting from irrigation projects so that storage needs for streamflow regulation for water quality control may be reduced.

11. The Dallas Creek Project is an integral part of the Colorado River Basin. Since the study of the Dallas Creek Project has been made in advance of a comprehensive study of the Colorado River Basin, the findings, presented in this report, are preliminary and subject to revision upon completion of comprehensive studies for water supply and water quality management in the Colorado River Basin.

III. DESCRIPTION OF PROJECT AND STUDY AREA

Proposed Project Development

The multipurpose project would provide storage for flood control, recreation, fishery, water quality control, municipal water and irrigation. A supplemental irrigation water supply will be provided for 13,717 acres and full service water supply for 14,908 acres, primarily located in Ouray County, Colorado (Figure 1, preceding back cover).

The principal feature of the project is Ridgway Reservoir. Ridgway Dam will consist of two sections-- a dam on the Uncompahgre River and a dike on Dallas Creek. The water behind each structure will merge to form one reservoir. Total capacity of the reservoir will be 140,000 to 150,000 acre-feet and will inundate the present town of Ridgway, Colorado.

Dallas Divide Reservoir will be located on Pleasant Valley Creek, a tributary of Dallas Creek. This reservoir will have a capacity of 17,200 acre-feet. A canal will collect surplus flows from the headwaters of several tributaries of Dallas Creek for storage in Dallas Divide Reservoir. Water will be conveyed by canal from this reservoir to project lands on Upper Log Hill Mesa. Also, a portion of the water stored in Dallas Divide Reservoir would supplement the water supply for presently irrigated lands in the Pleasant Valley and Dallas Creek area.

Turbine pumping will be used to pump water from Ridgway Reservoir to a canal on Log Hill Mesa. The pumping capacity will be 195 cubic feet per second (cfs). For each cfs pumped to Log Hill Mesa, about 3 to 4 cfs will be released to the Uncompahgre River. During the irrigation season a minimum of 320 cfs will be maintained in the Uncompahgre River at Colona, Colorado, while during the winter the flow at this point will average 50 cfs.

The Sneva Reservoir, to be located at an off-stream site between Cow Creek and Dry Creek, will have a capacity of 900 acre-feet. This reservoir is to supply the presently irrigated lands in the Cow Creek area with a full irrigation water supply.

The Tri-County Water Conservancy District has requested 15,000 acre-feet of yield from Ridgway Reservoir for municipal and industrial purposes under provisions of the Water Supply Act of 1958. This water would be provided for the towns of Montrose, Olathe, and Delta, Colorado.

Description of the Study Area

Boundary and Location

The Dallas Creek Project lies almost wholly within Ouray County in southwestern Colorado. It is near the headwaters of the Uncompahgre River which forms on the steep slopes of the San Juan Mountains at elevations exceeding 14,000 feet. Elevations drop to approximately 7,000 feet at the town of Ridgway and approximately 6,300 feet in the Uncompahgre River Valley at the Ouray-Montrose County line. Dallas Creek and tributaries form the major drainage area to the west, while Cow Creek drains the area to the east. In addition to Ouray County, the study area includes Montrose City and Olathe town in Montrose County, and Delta City in Delta County, 29, 41, and 54 river miles respectively from the proposed Ridgway Reservoir.

Soils[1]

Five major soil groupings are recognized in the study area. They consist of (1), Desert Sierozen; (2) Brown-chestnut; (3) Mountain Prairie-chestnut; (4) Gray wooded-Brown-Podzolic-Mountain Prairie; and (5) Alpine Meadow-Alpine Bog. Irrigated acreages in Ouray County occur primarily on groups 2 and 3. The soils in the stream valleys are generally heavier textured soils both from shale and sandstone, while the soils in the Log Hill Mesa area generally are lighter textured from sandstone. Internal soil drainage is a problem on most of the heavy, clay loam soils of the bottomlands where heavy seepage at the upland edges occurs. The proposed irrigation of new lands in the Log Hill Mesa area may require protective surface and internal drainage measures to control sediment loading and seepage.

Climate[2]

The climate of the study area is highly influenced by the San Juan Mountains. Temperatures are more severe in the high, rugged mountains to the south and comparatively mild to the north. January temperatures average about 28° F and the July average is about 65° F. Annual precipitation averages about 20 inches ranging from less than 10 inches in the north portion to about 40 inches in the south portion. The annual frost-free period in Ouray County averages about 128 days.

Transportation and Utilities

The study area is isolated from large populated areas such as Denver on the eastern slope at a distance of about 275 miles, and Salt Lake City to the west about 300 miles. U. S. Highway No. 550 traverses the study area, generally following the Uncompahgre River Valley and leaves the area's southern boundary at Red Mountain Pass summit. Approximately twelve local and interstate truck lines provide

service for the area. Continental Trailways Company serves the area and the Denver and Rio Grande Western Railroad provides rail service as far as Ridgway town. A commercial airport at Montrose City is served by Frontier Air Lines.

Electrical service is supplied by the Western Colorado Power Company and Delta-Montrose Rural Power Lines Association, Inc. Butane and propane suppliers are located in Montrose, Colorado. Communication service is provided by the Mountain States Telephone and Telegraph Company.

IV. THE ECONOMY

Present

The leading basic industries in the study area include agriculture and forestry, mining, and recreation. The economy is basically oriented to agricultural activities. Mining activity has declined since the late 1930's, but remains relatively important to the area. Recreation has been of increasing importance to the area.

Manufacturing activity has been increasing in importance to the study area during the past decade.

Population Characteristics

Population trends for the study area compared to the Gunnison River Basin and the State of Colorado, are shown in Table I. The study area's population increased by 6.2 percent from 1940 to 1950, followed by a decrease of 6 percent from 1950 to 1960. The loss in population during the 1950 to 1960 decade resulted from a net out-migration in Ouray County and Delta City. Montrose City experienced a small increase in population during this period.

The number of urban and rural non-farm residents increased from 1940 to 1950, but declined from 1950 to 1960 (Table II). Estimates of the population for January 1963,[4] however, indicate a reverse in this trend, particularly in the urban population. Farm population has declined continuously from 1940 to 1960 as compared to a similar trend for the State (Table II).

Relative increases in median family income for the study area from 1950 to 1960 compare favorably with that for the State of Colorado (Table II).

TABLE I

Population Trends - 1940 to 1960

Area and Counties	Year 1940	1950	1960	Percent Change 1940-1950	1950-1960
Study Area:					
Ouray County	2,089	2,103	1,601	.7	-23.9
City of Montrose	4,764	4,964	5,044	4.2	1.6
City of Delta	3,717	4,097	3,832	10.2	- 6.5
Town of Olathe	705	810	773	14.9	- 4.6
Total	11,275	11,974	11,250	+ 6.2	- 6.0
Gunnison River Basin:					
Delta County	16,470	17,365	15,602	5.4	-10.1
Gunnison County	6,192	5,716	5,477	- 7.7	- 4.2
Hinsdale County 1/	247	226	147	- 8.5	-35.0
Montrose County 1/	13,748	12,426	12,811	- 9.6	3.1
Ouray County	2,089	2,103	1,601	0.7	-23.9
Saguache County 1/	222	178	138	-19.8	-22.5
Total	38,968	38,014	35,776	- 2.4	- 5.9
State of Colorado:					
	1,123,296	1,325,089	1,753,947	+18.0	+32.0

Source: Gunnison-Uncompahgre Region, Report #1, Colorado State Planning Division, January 1962, and U. S. Bureau of the Census

1/ Estimated for portion of county within Gunnison River Basin

TABLE II

Population and Labor Force Characteristics
1940-1960

	Study Area			State of Colorado		
	1940	1950	1960	1940	1950	1960
Total Population						
Number	11,275	11,974	11,250	1,123,296	1,325,089	1,753,947
Percent	100.0	100.0	100.0	100.0	100.0	100.0
Rural Farm						
Number	1,138	455	334	251,692	198,181	127,561
Percent	10.0	4.0	3.0	22.4	15.0	7.3
Rural Non-Farm						
Number	1,656	2,458	2,040	280,848	295,590	333,596
Percent	15.0	21.0	18.1	25.0	22.3	19.0
Urban						
Number	8,481	9,061	8,876	590,756	831,318	1,292,790
Percent	75.0	75.0	78.9	52.6	62.7	73.7
Total Civilian Labor Force	4,135	4,290	4,085	418,293	497,648	652,805
Employed						
Number	3,329	4,041	3,807	346,535	476,644	626,769
Percent of Labor Force	80.5	94.2	93.2	82.8	95.8	96.0
Unemployed						
Number	806	249	278	71,758	21,004	26,036
Percent of Labor Force	19.5	5.8	6.8	17.2	4.2	4.0
Median Income per Family				NA*	$ 3,079	$ 5,780
Delta County	NA*	$1,931	$3,623			
Montrose County	NA*	$2,221	$4,451			
Ouray County	NA*	$2,769	$4,133			

Source: U. S. Census of Population

*Not Available

Labor Force Characteristics

The total labor force has experienced a decline of 4.8 percent from 1950 to 1960 (Table III). Montrose City, however, experienced a 2.6 percent increase in total labor force during this period. The unemployment rate in the study area increased from 5.8 percent in 1950 to 6.8 percent in 1960.

Agriculture, mining, and manufacturing accounted for 20.6 percent of the labor force in 1960. Agriculture and mining employment dropped from 1950 to 1960 while manufacturing employment increased from 5.2 percent of the labor force in 1950 to 7.5 percent in 1960. All other industry divisions increased in employment from 1950 to 1960, except construction, transportation, and utilities. Almost half of the labor force was employed in the trades and service categories during 1960.

Land Use and Ownership

Irrigated crop production consists primarily of legume and grass mixtures for hay and pasture. The private and public range lands are used primarily for livestock grazing.

Ouray County contains 345,600 acres out of which approximately 52.2 percent is in private ownership, 46.6 percent is in Federal ownership, and 1.2 percent is in State and local government ownership. Over 80 percent of the land in private ownership is included in farms. National Forest lands comprise 79 percent and Bureau of Land Management lands, 21 percent of all Federally-owned land.

Agriculture and Forestry

Agriculture and forestry have had a predominating influence in the study area for many years. Agricultural activity centers around livestock production supported by the production of legume and grass mixtures for hay and pasture.

Agriculture in Ouray County is faced with a relatively short-growing season and poor seasonal distribution of irrigation water. Total value of all farm and forest products amounted to about $920,000 in 1959.[15] Total irrigated land has averaged about 17,000 acres annually during the period 1950 to 1959. The number of farms decreased from 131 in 1950, to 93 in 1959, while total farm labor has remained fairly constant.

TABLE III

Civilian Labor Force by Major Industry Division, Dallas Creek Study Area
1950-1960

Industry	1950 Number	1950 Percent	1960 Number	1960 Percent	Percent of Change 1950-1960
Agriculture	483	11.3	333	8.2	-31.0
Mining	307	7.2	201	4.9	-34.5
Construction	311	7.2	255	6.2	-18.0
Manufacturing	223	5.2	306	7.5	37.2
Transportation, Communication and Utilities	318	7.4	187	4.6	-41.2
Wholesale and Retail	1,021	23.8	1,028	25.2	0.7
Finance and Real Estate	138	3.2	184	4.5	33.3
Services	914	21.3	921	22.5	0.8
Public Administration	251	5.9	279	6.8	11.5
Industry not Reported	75	1.7	113	2.8	50.7
Total Employed	4,041	94.2	3,807	93.2	- 5.8
Unemployed	249	5.8	278	6.8	11.6
Total Labor Force	4,290	100.0	4,085	100.0	- 4.8

Source: U. S. Bureau of Census

Agriculture depends heavily upon National Forest and Bureau of Land Management lands for supplemental grazing during the summer months. In addition, the national forest provides saw timber for local sawmills. The U. S. Forest Service has scheduled an estimated 24 million board feet for harvesting by 1971.(6)

Mining

The value of mineral production in the study area has increased from about $603,000 in 1955 (7) to slightly over $2,710,000 in 1962.(8) Minerals produced in order of value during 1962 included zinc, copper, lead, gold, silver, sand, and gravel.

Coal production has never been of significant importance to the study area, however, coal reserves on and near the periphery of the study area were estimated at 75.4 billion tons in 1953.(9)

Uranium and vanadium mining and processing has been active in recent years in the eastern part of Montrose County.

Manufacturing

The manufacturing industry employed 5.2 percent of the labor force in 1950 and 7.5 percent in 1960. Out of a total of 81 firms in operation during 1961, food and kindred products accounted for 25, and lumber and wood products accounted for 33. The balance was distributed among various other subdivisions of the manufacturing industry. Firms manufacturing nondurable goods employed 72 percent of total manufacturing employment.

Outdoor Recreation

The study area is the center of increasingly heavy recreation use. Often referred to as "the Switzerland of America," the area holds many attractions for tourists and visitors, including the scenic beauty of the San Juan Range, exploring historic townsites and mines, jeep cavalcades, hunting, camping, and picnicking. The Uncompahgre Plateau is known for excellent deer hunting. Numerous elk are taken each year in this area. It is estimated that 20 percent of Colorado's wild turkey harvest came from this area in 1961.(1) Fishing is expected to increase rapidly as improvements in water quality take place.

It is estimated that the number of tourists visiting Colorado increased by 133.6 percent from 1956 to 1961, and recreational expenditures increased by 180.6 percent.(10) Assuming the Gunnison-Uncompahgre Region accounts for 15 to 20 percent(11) of the State's total, the economic impact to the region is of great importance.

The impact of recreational activity on the local economy is reflected primarily in the retail trade and service sectors through direct expenditures, as well as providing additional employment.

Commercial and Government Activities

Except for some decrease in construction, transportation and utilities, employment in all other commercial sectors increased during the period 1950 to 1960 (Table III). Recent trends in construction activities indicate considerable growth for the economy, particularly in the Montrose City area. This is attributed primarily to increased Federal activity in large dam construction on the Gunnison River and increased recreational activity.

A number of Federal and State Government agencies maintain offices in Montrose and Delta. Employment in government activities represented 6.8 percent of the labor force in 1960. Increased employment in the government sector can be expected in the next few decades.

The Western Colorado Power Company and the Delta-Montrose Power Association serve the urban and rural area with a complete system of transmission lines.

Future Growth

The economic projections were based on the general assumption that the Nation and the Colorado River Basin will experience a relatively high level of employment, stable prices, and continued development and adoption of technology consistent with needs of an increasing population.

Future Population and Labor Force

Future population and labor force estimates for the study area are shown in Table IV. The agriculture industry is expected to decline in relative importance throughout the projection period. Employment in agriculture, however, is expected to increase to 1985 with the development of the Dallas Creek Project and to decline thereafter as a result of anticipated efficiency and productivity increases and the trend to larger farm units. Mining employment is expected to increase from 4.9 percent of the labor force in 1960 to 5.4 percent in 1985 and to remain relatively stable as a percent of the labor force thereafter. Manufacturing employment is expected to double by 1985, reaching peak growth rate in about 1990 or 2000.

Increased employment is expected thereafter, but at a reduced rate. Recreational impact on the local economy, reflected primarily in the retail trade and service sectors, is expected to be of major importance throughout the projection period. The transportation and utilities sectors are expected to increase at a higher rate during the 1970-1990 period and increase in proportion to the basic industries thereafter. Employment in government is expected to increase rather rapidly during the 1960-1985 period. An increase at a reduced rate is expected following 1985.

The number of unemployed persons is estimated to drop from 6.8 percent of the labor force in 1960 to 4.0 percent of the labor force by 1985 and to remain at about 4.0 percent of the labor force after 1985.

Urban residents in the study area are expected to increase from 78.9 percent of the total population in 1960 to 84.6 in 2060. The percentage of rural residents is expected to decline; however, an increase in absolute numbers is expected throughout the period (Table IV). Population trends and projections for the study area compared to the State of Colorado and the United States are shown in Figure 2.

Agriculture: The number of farms and farm population is expected to increase in initial stages of the projection period with development of the proposed Dallas Creek Project. However, farm population, farm labor force and farm numbers are expected to decline during the 100-year projection period. Agricultural incomes are expected to increase in line with past trends for the industry involving increases in technology, productivity, and managerial skills as well as the trend to larger farm units.

Minerals: Small increases in mining employment throughout the projection period are based upon increased activity in the base metals; future growth for the coal industry, particularly the possibility of producing chemical products from coal; and development of oil shale reserves.

Industrial minerals and mineral fuels now having a predominant place in the State's mineral industry will have an indirect impact on the study area. Uranium, vanadium, coal, oil shales, and gas have been only partially developed to their ultimate capacity. (8)

TABLE IV

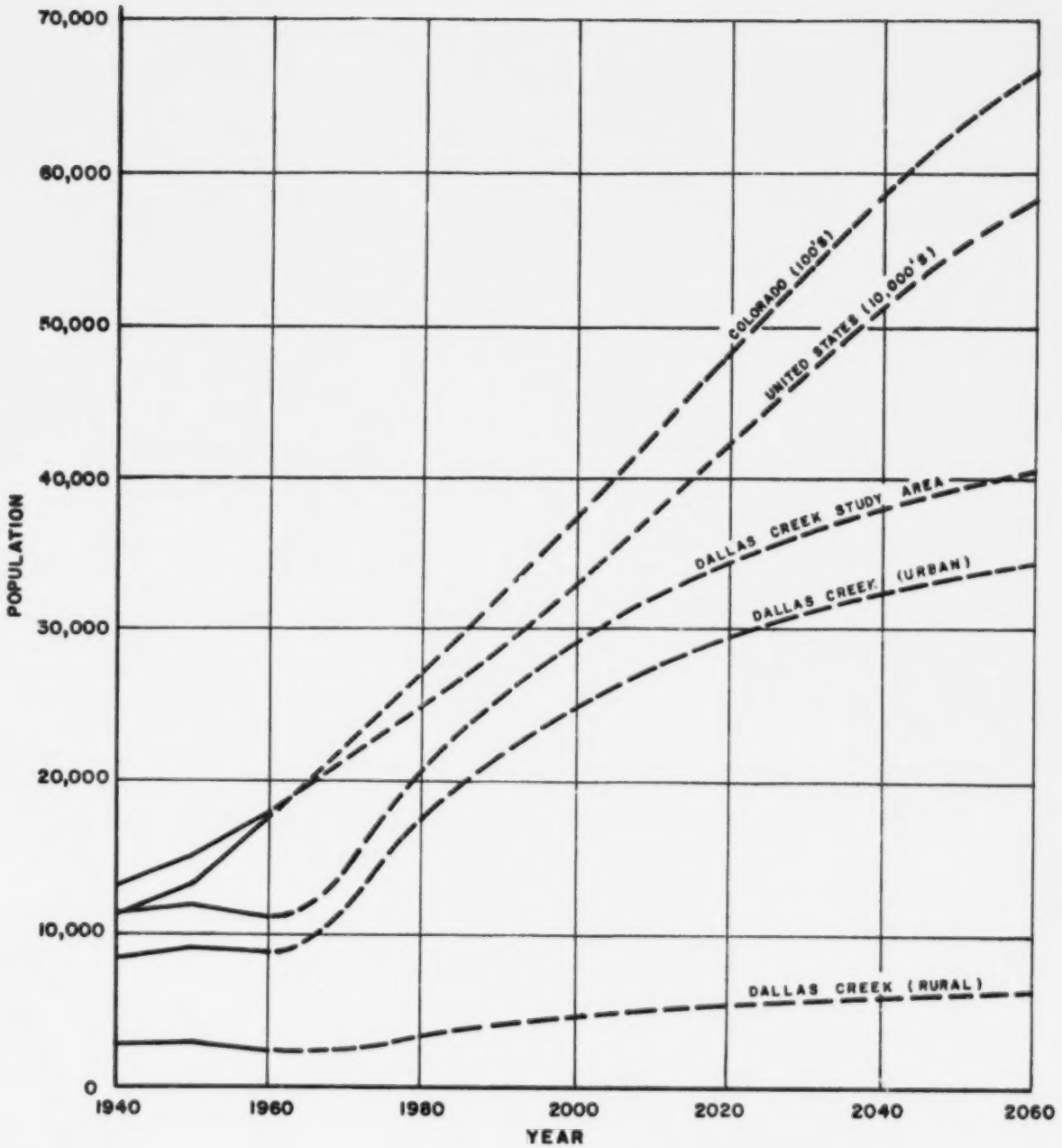
Population and Employment by Major Industry Divisions, Dallas Creek Study Area
1960 and Projections for 1985, 2010, and 2060

	1960		1985		2010		2060	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total Population	11,250	100.0	23,400	100.0	32,450	100.0	40,900	100.0
Urban Residents	8,876	78.9	19,600	83.8	27,500	84.7	34,600	84.6
Rural Residents	2,374	21.1	3,800	16.2	4,950	15.3	6,300	15.4
Employment Distribution								
Agriculture	333	8.2	480	5.7	360	3.1	250	1.7
Mining	201	4.9	450	5.4	600	5.1	800	5.4
Manufacturing	306	7.5	600	7.2	1,020	8.6	1,500	10.1
All Other Industries	2,967	72.6	6,485	77.7	9,345	79.2	11,750	78.8
Employed	3,807	93.2	8,015	96.0	11,325	96.0	14,300	96.0
Unemployed	278	6.8	335	4.0	475	4.0	600	4.0
Total Labor Force	4,085	100.0	8,350	100.0	11,800	100.0	14,900	100.0

Manufacturing: Growth in the manufacturing industry is expected to take place in both the durable and nondurable goods categories. The manufacture of nondurable goods is expected to remain predominant in the area due to its raw material production of agricultural and timber products. In view of present and proposed water and power development projects, the area is expected to be in a competitive position to attract selected manufacturing industries which serve nonlocal markets.

Tourist-Oriented Industries: Continued expansion in retail trades and services is expected as a result of recreational activity, and from expected increases in the basic industries. Recreational activity is expected to play an important role in the area's economy throughout the projection period.

Other Commercial and Government Activities: Growth in the construction, transportation, utilities, and finance sectors is expected in proportion to anticipated growth in the basic industries. Construction activity is expected to increase sharply during the initial period as a result of Federal activities and its related impacts followed by a decline and further expansion coincident with the area's overall economic growth. Increases in the Government sector will be influenced by anticipated Federal multipurpose water storage projects, increased local and state government activities, and expansion in planning and management of Federally-owned lands.



DALLAS CREEK PROJECT

POPULATION

DEPT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

GPO 836-378

FIGURE 2

V. WATER SUPPLY

Uses

Irrigation is the principal use of the water from the Uncompahgre River and its tributaries. Together with the water imported from the Gunnison River through the Gunnison Tunnel, the water provides irrigation for about 111,000 acres of land.[5]

No community uses the Uncompahgre River as a source of municipal supply. Ground water, tributaries within the basin, or sources outside the Uncompahgre Basin are used.

Fishing activity in the Uncompahgre River is limited to a "put and take" basis from Ouray to Ridgway due to poor water quality. The Colorado Game and Fish Department also stocks the reach from Ridgway to Montrose where fishing is somewhat improved over that upstream. Below Montrose, the high water temperatures and silt load due to the return irrigation flows prevents the use of the river for fishing.[12] With improved water quality, fish propagation is anticipated.

Water Quality

Mineral quality data of surface waters in the study area are summarized in Table V, VI, and VII.

The data indicate that the East Fork of Red Mountain Creek and the stream below the confluence of the east and west forks are polluted as a result of acid mine drainage; pH values as low as 2.8 were obtained. The acid from abandoned mine shafts and ground water seepage in the vicinity of old mine workings contains a high level of dissolved metals. After Red Mountain Creek is diluted by the Uncompahgre River and other tributaries of the Uncompahgre, the pH increase, along with the aeration, result in the dissolved metals precipitating out of solution. These precipitated metals coat the bottom of the stream or are carried downstream in suspension. The effects of the pollution on biological life are apparent at all points downstream to the proposed Ridgway Dam site.

A biological survey was carried out by the Public Health Service to determine the biological condition of streams in the area. Table VIII indicates that the biological condition of the Uncompahgre River above Dallas Creek is not conducive to fish propagation. Although the number of bottom organisms per unit area of streambed increases

TABLE V

Chemical Quality of Surface Waters in Study Area

Sampling Station (Number of Samples) Date Samples Collected	EC (micromhos per centimeter)	pH	TDS	Ca	Mg	Na	HCO_3	Cl	SO_4
			(milligrams per liter)						
Red Mountain Creek	990	4.1	805	161	11	7	0	1	445
near Ironton, Colorado (3)	676	3.9	547	105	7	5	0	0	334
9/58-2/59	789	4.1	653	126	9	6	0	1	389
Dallas Creek near	1173	8.5	945	190	50	38	254	6	572
Ridgway, Colorado (47)	416	7.5	294	64	12	10	101	0	96
9/58-2/63	641	8.2	488	95	20	15	153	2	224
Uncompahgre River	1005	8.4	796	148	28	50	204	11	472
near Ridgway, Colorado (47)	301	7.9	184	43	5	8	57	1	86
9/58-2/63	530	8.1	352	77	12	20	103	3	177
Cow Creek near	339	8.7	250	42	10	19	121	2	67
Ridgway, Colorado (20)	83	8.0	52	10	1	4	35	0	7
4/59-1/61	116	8.1	71	14	2	6	50	1	15
Uncompahgre River	917	8.3	698	131	29	49	207	9	390
at Colona, Colorado (23)	327	7.5	202	37	7	10	76	1	81
2/61-2/63	546	8.1	377	74	15	21	115	3	183
Uncompahgre River	2778	8.6	2526	303	129	324	304	34	1520
at Delta, Colorado (34)	988	7.6	754	102	32	65	114	8	386
4/59-4/62	1859	8.1	1567	189	68	162	188	17	886

Source: U. S. Bureau of Reclamation, Region 4. Upper, middle, and lower values for each station are the maximum, minimum, and weighted mean value, respectively.

TABLE VI

Heavy Metals Concentrations
Uncompahgre River near Ridgway, Colorado

Sampling Date	Cu	Pb	Zn	Se	As	Soluble Fe	Precipitated Fe
				(milligrams per liter)			
2-15-61				.003	.006	0	.5
4- 5-61				.009	.006	0	2.5
5- 2-61				.002	0	0	4.2
6- 9-61				.005	0	0	1.7
7-13-61				.002	.002	0	.3
8- 8-61				0	.006	0	.6
9-15-61				0	0	0	.7
10- 6-61				0	.002	0	1.1
11- 7-61				.005	0	0	1.1
12- 4-61				.005		0	.9
1- 4-62				.002		0	.6
2-12-62						0	1.6
3- 7-62						.05	.4
4- 3-62						0	.6
5- 2-62	.01	.007	.040				
6- 4-62	Nil	Nil	.013				
7- 3-62	Nil	.008	.013				
8- 1-62	Nil	Nil	.013				
9-13-62	Nil	Nil	.05				
10- 1-62	Nil	.009	.200				

Source: Bureau of Reclamation, Region 4, Salt Lake City, Utah

TABLE VII

Water Quality Data for Dallas Creek Project Area

Sampling Station	Date	Mn	Fe	Cu	Zn	Pb	As	Se	DO	TDS	Hardness as $CaCO_3$	Acidity as $CaCO_3$	Electrical Conductivity (micromhos per centimeter)	pH
		(milligrams per liter)												
Red Mountain Creek, West Fork above Idarado Mill	9-18-62	0	0.07		0.08									6.8
	10- 9-62								9.0		46		190	6.8
Red Mountain Creek, East Fork, above Idarado Mill	10- 9-62		93	2.5	0.25	0.20			8.0		70		1,200	2.8
Red Mountain Creek, 1/2 mile below Idarado Mill	9-18-62	6.2	52	2.2	5.5	0.18								2.9
	10- 9-62		62	2.9	2.2	0.16	Nil		7.0		110		1,250	3.0
	5- 8-63	0.8	0.7	0.7	1.7	Nil				191	65	65		3.4
Abandoned Mine Shaft Drainage	10- 9-62													2.8
	5- 8-63	6.3	82	1.4	13	Nil				2,220	590	103		2.7
Red Mountain Creek at Ironton Park Reservoir Site	9-18-62			0.6	2.8	0.12								3.5
	10- 9-62								8.6		315		700	3.5
	5- 8-63	1.0	0.08	0.4	0.94	Nil				211	99	37		3.7
Uncompahgre River above Confluence w/Red Mountain Creek	9-18-62													7.3
	10- 9-62		0.03	Nil	0.01	Nil			9.4		106		260	7.5
Uncompahgre River above Canyon Creek	9-19-62			0.4	1.2	Trace								4.6
	10- 9-62	1.3	1.3						10.0		170		700	4.8
Canyon Creek, 1/4 mile below Camp Bird Tailings Pond	10- 9-62		0.01	Nil	0.18	Nil	Nil		9.6		142		250	7.5
Uncompahgre River at 7th Street Bridge, Ouray	8/27 - 9/ 1/62	0.7		0.01	0.56	0.02								7.8
	9-27-62	0.6	2.8	0.06	0.20					282	180		400	7.4
	10-25-62	0.0	2.7	0.12	0.54				9.6	338	209		490	6.9
	12- 6-62	0.7	2.1	0.12	0.48					435	287		700	7.4
Uncompahgre River, 2 miles below Ouray	9-19-62			0.04	0.55			Nil						7.8
	10-10-62								8.6		245		600	7.2
	5- 8-63	0.34	0.15	0.01	0.06	Nil				154	81			7.3
Uncompahgre River 6 miles below Ouray	9-19-62	<0.1	0.09	0.01	0.17									8.0
	10- 9-62	0.34							8.8		240		580	7.6
Uncompahgre River above Dallas Creek	7-26-62									465	305		675	7.8
	8/27 - 9/ 1/62	0	0.05								327		694	8.0
	9/19/62	0	0.06					Nil						8.1
	10- 9-62	<0.1	0.03	Nil	0.01	Nil			8.8		375		750	8.0
	10-25-62								9.8	513	318		750	8.0
	12- 6-62									609	391		900	7.8
Dallas Creek, 1 mile above mouth	10-10-62								8.8		380		760	8.2

Source: Colorado River Basin Water Quality Control Project, U. S. Public Health Service, Denver, Colorado

TABLE VIII

Bottom Animals, Upper Uncompahgre River Basin*

Sampling Station	Ephemeroptera (Mayflies)	Plecoptera (Stoneflies)	Heriptera (Water Bugs)	Trichoptera (Caddisflies)	Coleoptera (Water Beetles)	Diptera (True Flies)	Turbellaria (Flatworms)	Gastropoda (Snails)	Others	Animals per Square Foot
Red Mountain Creek, West Fork above Idarado Mill	107	30		28			8			64
Red Mountain Creek, 1/2 mile below Idarado Mill				1						<1
Red Mountain Creek at Ironton Park Reservoir Site						1				<1
Canyon Creek, just above Confluence with Uncompahgre		3				28				10
Uncompahgre River just above Entrance of Red Mountain Creek **	27	30		2						30
Uncompahgre River just above Entrance of Canyon Creek						1				<1
Uncompahgre River, two miles below Ouray		3	1	1		10				5
Uncompahgre River, six miles below Ouray	5	2		26		1				11
Uncompahgre River above Entrance of Dallas Creek	28	9		59	2	10				36
Dallas Creek, one mile above Confluence with Uncompahgre	48	27		352	91	279			8	269

*3 square foot sample
**2 square foot sample

from Ouray to Ridgway, the numbers are not indicative of a healthy stream. On the contrary, Dallas Creek was very good from the biological standpoint. Improvement of water quality in the Uncompahgre River below Ouray would be necessary to obtain the maximum benefit from fishing at present and after construction of Ridgway Reservoir.

Data on heavy metals indicate that under normal flow conditions the metals concentrations at the Ridgway dam site are reduced to levels which are below the limits shown in the Public Health Service Drinking Water Standards.[13] However, manganese concentrations would be above these limits at the beginning of the backwater of the proposed reservoir. Further upstream the iron and manganese concentrations were particularly high; values of 2.8 milligrams per liter (mg/l) and 0.7 mg/l, respectively, were obtained.

Maximum values for sulfates and total dissolved solids exceed the limits cited in the PHS Drinking Water Standards[13] at the sampling stations for Dallas Creek and the Uncompahgre River near Ridgway (Table V). The water quality of the Uncompahgre River at Colona is very similar to that in the river near Ridgway, however, between Colona and Delta the river becomes seriously polluted. The primary cause of this pollution is the entrance of saline irrigation return flows from the Uncompahgre Project between Montrose and Delta, Colorado.

With a few exceptions, soils on the east side of the Uncompahgre River in the area of the Uncompahgre Project are derived from Mancos shale.[14] Mancos shale soils are noted for their extremely high contribution of salts when they are leached with water.

Effect of Project Operations

Chemical Quality

The combined flow of the Uncompahgre River above Ridgway, and Dallas Creek and diversions from Cow Creek will make up most of the storage in Ridgway Reservoir. The concentrations when weighted for flow, assuming uniform mixing of the waters, provides an estimate of the resultant concentrations to be released from Ridgway Reservoir. Calculations indicate that expected sulfate, total dissolved solids, and hardness would be about 150 mg/l, 300 mg/l, and 200 mg/l, respectively. The sulfate and total dissolved solids values are within the limits of the Public Health Service Drinking Water Standards. Water with a hardness of 200 mg/l is usually considered a hard water. Softening to 100-125 mg/l would be desirable for domestic use.

Based upon limited available data, the weighted annual average concentration of total dissolved solids at Colona has been about 370 mg/l. Under project operation it is anticipated that the concentration will be reduced about 5%. At Delta, total dissolved solids have averaged about 1,600 mg/l and are expected to increase to about 2,050 mg/l with the project. On a monthly basis, concentration of total dissolved solids at Colona will be reduced during the period October through April; increased during the months of May, June, and July; relatively unchanged during August and September with the project. At Delta, concentrations of total dissolved solids will be increased all months with the exception of August, September, and October, which will be reduced slightly under project operation.

With Ridgway Reservoir in operation, it is possible that the water in the bottom part of the reservoir may be anaerobic. If so, metals such as iron and manganese which had previously precipitated would tend to go back into solution since the reduced state of metal would be more soluble. To minimize the possibility of excessive concentrations of metals getting through the proposed municipal water intake, and to provide a greater flexibility of operation, a two-level water intake is recommended.

An analysis of water quality data indicates that the water stored in project reservoirs would be suitable for irrigation purposes. However, the storage would have the effect of providing poorer water quality than at present during the high run-off periods of May and June and improving downstream water quality during the other months because of the mixing of better quality water of May and June with that of the remainder of the year. The U. S. Department of Agriculture (15) indicates that improved water quality will decrease the volume of irrigation water necessary to maintain a favorable salt balance in the soil. An improvement in water quality could result in a large savings in water and substantial benefits to a project. Calculations show that the quality of water available for irrigation during late summer and early fall will be improved under project operation. However, during the early part of the irrigation season, the reverse is true and thus will necessitate using more water to maintain a favorable salt balance in the soil. In this instance the benefits which could be applicable to improvement in water quality are offset by the greater quantity of poorer water required.

Aquatic Life

The biological data previously presented indicate that the Uncompahgre River above Ridgway is not suitable for the growth and propagation of fish life. Toxic constituents which are relatively high in concentration during low flow periods, along with the blanket of metal precipitates on the bottom of the stream, undoubtedly causes the problem. Aquatic organisms are more sensitive than human beings to many toxic materials. Unless corrective measures are taken, Ridgway Reservoir will be marginal in its ability to support aquatic life.

From Ridgway Reservoir to Montrose the water quality in the Uncompahgre River is expected to be satisfactory for aquatic life. The return flow from irrigation on Log Hill Mesa will tend to increase the suspended solids in the Uncompahgre River, however, proposed Bureau of Reclamation releases from Ridgway Reservoir are expected to be sufficient to maintain a fishery in the Uncompahgre River downstream to Montrose.

Below Montrose the water quality in the Uncompahgre River will support fish life, but prevents propagation of fish.[12] Excessive sediment and high temperature of the irrigation return flows in this reach cause this condition. The Dallas Creek Project will not improve the situation.

Recreation

Fishing, boating, and other forms of recreational use will be made of project reservoirs. The City of Ouray, Colorado, at present discharges its raw sewage into the Uncompahgre River. Before any recreational use is permitted of Ridgway Reservoir, Ouray must provide secondary treatment of its sewage so as not to endanger the health of persons using the reservoir facilities.

Changes in Project

The Bureau of Reclamation has made a preliminary study of a proposed dam located at Ironton Park on Red Mountain Creek above Ouray, Colorado. Based on power benefits alone, the construction of Ironton Park Dam would be a marginal proposition. However, the water quality benefits that would accrue with Ironton Park Reservoir may warrant inclusion of this reservoir in the project.

The Bureau of Reclamation proposal would divert good quality water from the Uncompahgre River above its confluence with Red Mountain Creek to Ironton Park Reservoir to obtain power benefits

from both flows. A study was made by the Public Health Service to determine the effects of mixing waters from the upper Uncompahgre River and Red Mountain Creek. This work was carried out by the Colorado River Basin Water Quality Control Laboratory. Water from the Uncompahgre River would increase the pH of the water within the reservoir and precipitate the dissolved metals contained in Red Mountain Creek. Thus the precipitation of the metals would occur within the reservoir, rather than in the Uncompahgre River from above Ouray to Ridgway. This not only would permit full benefits to be achieved for a Ridgway Reservoir fishery, but would also permit development of the Uncompahgre River from Ouray to Ridgway Reservoir for fishing. In collaboration with the U. S. Fish and Wildlife Service, (16) increased fishery benefits due to improvement in water quality are estimated to be $9,300 annually in the stream above the reservoir, and $40,000 annually within Ridgway Reservoir.

In addition to fishery benefits, there would be a significant intangible water quality benefit to the use of Ridgway Reservoir as a water supply, if Ironton Park Reservoir is constructed. A safety factor would be provided by holding the heavy metals within Ironton Park Reservoir rather than allowing these metals to flow down the Uncompahgre River. Even though the limited water quality data available show the water at Ridgway Reservoir site to be generally within the limits of the Public Health Service Drinking Water Standards, the Colorado State Health Department and the Public Health Service are reluctant to give blanket approval for the continuous domestic use of the reservoir water. A water which does not permit the propagation and growth of aquatic life due to the presence of heavy metals in concentrations toxic to aquatic life, would be unpalatable for human consumption.

In addition to diverting water from the upper Uncompahgre River to Ironton Park Reservoir, it would be desirable to also divert water from Canyon Creek to the reservoir. In this way, there would be further improvement of water quality below Ironton Park Reservoir, as well as increased power benefits.

VI. MINIMUM FLOW REQUIREMENTS

Under provisions of the Federal Water Pollution Control Act, Public Law 84-660, as amended by Public Law 87-88, in the survey or planning of a reservoir by any Federal agency, consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control. It is expressly stated that any such storage and water releases shall not be provided as a substitute for adequate treatment or other method of controlling wastes at their sources.

Discharge of wastes, even when treated to maximum practical limits, will cause an unsatisfactory quality condition when the waste assimilation capacity of receiving waters is exceeded. This condition generally occurs during periods of low flows and warm temperatures and may be avoided by the provision of additional dilution water. It is essential that recognition be given to the need for flows which must prevail in receiving streams if the quality of their waters is to be maintained at acceptable levels.

Table IX summarizes the municipal water sources and waste discharges in the study area. Of the two industries in the area which are not connected to a municipal system, the Idarado Mining Company above Ironton Park has no discharge and the processing section of the Camp Bird Mining Company on Canyon Creek was recently closed down.

Calculations indicate that only 0.6 cfs dilution water would be required to dilute Ouray sewage, after treatment, increasing to 1 cfs by the year 2060. This small amount would be available from natural run-off, even with the Ironton Park portion of the project in operation. Table X indicates the minimum flow required in the Uncompahgre River below Montrose to assimilate the treated Montrose sewage effluent and to maintain dissolved oxygen concentrations of at least 5 mg/l.

TABLE IX

Municipal Water Sources and Waste Discharges

Town	River Mile	Estimated Present Population	Water Source	Sewage Treatment	Estimated PE* Reaching Stream	Receiving Stream
Ouray	67.2	785-1200 Seasonal	Weekawken Reservoir and Springs	None	1200 peak	Uncompahgre River
Ridgway	56.8	250	Springs	Individual	0	--
Colona	42.8	50	Individual Wells	Individual	0	--
Montrose	26.8	5100	Summer-Gunnison River Winter-Cimarron Creek	Secondary	1000	Uncompahgre River
Olathe	14.4	775	West Fork Dry Creek	None	775	Uncompahgre River
Delta	1.2	3900	Grand Mesa	Lagoon	400	Uncompahgre River

*Population Equivalent

TABLE X

Dilution Water Required Below Montrose, Colorado

Time	Flow Required, cfs
Present	7
1976	14
1985	17
2010	26
2060	37

Based upon historical streamflow records (1912-1962), minimum daily and average monthly flows in the Uncompahgre River near Colona have exceeded 37 cfs about 99 percent of the time. Under project operation minimum flows are expected to average 50 cfs during the winter months.

As previously noted, the water in the Uncompahgre River is seriously degraded between Colona and Delta. Protecting and improving the water quality of the Uncompahgre River is necessary if the area's potential for economic growth is to be realized.

Flow regulation is necessary to maintain water quality in the lower Uncompahgre River. If flows are maintained at Delta for water quality control, points upstream will be taken care of as well. With streamflow regulation the lower Uncompahgre River would have lower concentrations of dissolved solids, hardness,biochemical oxygen demand, bacteriological density,and temperature.

To reduce the high levels of total dissolved solids in the Uncompahgre River at Delta by using water from Ridgway Reservoir (approximately 300 mg/l total dissolved solids), or other water of equivalent quality, 74,000 acre-feet of dilution water would be required annually to maintain existing water quality with project operation. To reduce concentrations of total dissolved solids to 1,000 mg/l at Delta would require 197,000 acre-feet without the project, and 234,000 acre-feet with the project. Table XI shows the computed dilution water requirements at Delta, by months, based upon the Bureau of Reclamation's project operation study,* historical period (1947-61).

*September 6, 1963

TABLE XI

Dilution Water Requirements at Delta, Colorado
for Water Quality Control*
(in 1,000 acre-feet)

Month	Uncompahgre River Historical Flows: Average 1/	Uncompahgre River Historical Flows: Adjusted for Project 2/	Dilution Water for Quality Control 3/: Without Project 4/ To Maintain TDS of 1,000 mg/l	Dilution Water for Quality Control 3/: With Project 5/ To Maintain Existing TDS	Dilution Water for Quality Control 3/: With Project 5/ To Maintain TDS of 1,000 mg/l	Total Flow Requirement: Without Project To Maintain TDS of 1,000 mg/l Columns 2+4	Total Flow Requirement: With Project To Maintain Existing TDS Columns 3+5	Total Flow Requirement: With Project To Maintain TDS of 1,000 mg/l Columns 3+6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	16.9	12.6	24.7	3.5	26.7	41.6	16.1	39.3
December	9.4	5.8	19.0	2.4	19.0	28.4	8.2	24.8
January	7.7	4.8	15.0	2.2	15.6	22.7	7.0	20.4
February	7.2	4.5	14.0	1.9	14.8	21.2	6.4	19.3
March	8.2	4.4	15.9	2.6	16.2	24.1	7.0	20.6
April	16.5	13.7	14.7	.6	13.0	31.2	14.3	26.7
May	22.5	19.5	0	33.0	10.9	22.5	52.5	30.4
June	32.7	15.7	6.2	26.0	34.0	38.9	41.7	49.7
July	16.0	15.0	22.1	1.8	24.9	38.1	16.8	39.9
August	14.6	15.8	22.4	0	20.3	37.0	15.8	36.1
September	19.4	21.2	19.6	0	17.9	39.0	21.2	39.1
October	21.3	22.3	23.4	0	20.7	44.7	22.3	43.0
TOTALS	192.4	155.3	197.0	74.0	234.0	389.4 6/	229.3 7/	389.3 6/

* Conveyance losses, evaporation, etc., not included

1/ Computed from USGS Streamflow Records 1947-61

2/ Adjusted to reflect Project Operation 1947-61 (Bureau of Reclamation Project Study 9-6-63)

3/ Computed on basis of dilution water equivalent to water from proposed Ridgway Reservoir (TDS about 300 mg/l)

4/ Additional water over and above streamflow shown in Column 2 without adding new land to presently irrigated

5/ Additional water over and above streamflow shown in Column 3

6/ Based upon 1939-62 streamflow records - this flow exceeds available water supply in the Uncompahgre River Basin

7/ Based upon 1939-62 streamflow records - this flow could be met about 20% of the time

A reduction in total requirements for storage for streamflow regulation for water quality control could be expected if full consideration is given to reducing the total load of dissolved solids on the Uncompahgre River caused by present and future irrigation projects in the area. Among other possibilities, such reduction may result from improved farm management practices as well as removing small areas that may be producing a large part of the salt load. A study of the means for reducing the salt loading on the Uncompahgre River during advanced planning of the Dallas Creek Project is recommended. As stated in Public Law 660, as amended, "any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source." If such control is feasible, it will have economic benefits, not only in the Uncompahgre River, but also for downstream water users.

VII. ECONOMIC BENEFITS

The Dallas Creek Project is an integral part of the Colorado River Basin. Since this study has been made in advance of a comprehensive study of the Colorado River Basin, certain overall effects (beneficial and adverse), attributable to water quality control must await subsequent confirmation. This study does not include the effect of the Uncompahgre River on the Gunnison River. However, any improvement in water quality of the Uncompahgre River will reduce the concentration of total dissolved solids in the Gunnison River and in turn the Colorado River. A reduction in concentration of total dissolved solids would be beneficial to downstream water users.

Annual dilution water requirements to maintain existing water quality (about 1,600 mg/l TDS) at Delta, with the Dallas Creek Project, and requirements to maintain total dissolved solids of 1,000 mg/l at Delta without and with the Dallas Creek Project are as follows:

	Annual Dilution Water Requirements at Delta* (acre-feet)
To maintain existing TDS (about 1,600 mg/l) with Project	74,000
To maintain 1,000 mg/l, TDS without Project	197,000
To maintain 1,000 mg/l, TDS with Project	234,000

A review of historical streamflow data indicates that streamflows are inadequate to meet the above requirements. However, a reduction in these requirements could be expected through improved farm management practices, as well as removing small areas of presently irrigated lands that may be producing a large part of the existing salt load, thereby reducing total dissolved solids in the Uncompahgre River.

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*Considering dilution water to be equivalent in quality to Ridgway Reservoir water

In view of the above inadequacies and this study preceding a comprehensive study of the Colorado River Basin, no value has been assigned to storage of water for regulation of streamflow for the purpose of water quality control.

Direct water quality control benefits attributable to the Ironton Park Reservoir as an alternate plan would be as follows:

	Annual Benefits
Improvement of Uncompahgre River for fishing from Ouray to Ridgway Reservoir	$ 9,300
Improvement of Ridgway Reservoir for fishing	$ 40,000
Total	$ 49,300

These benefits are considered widespread in scope and are nonreimbursable as public benefits for fishing would result from improvement of about ten miles of the river above Ridgway Reservoir and improvement directly to Ridgway Reservoir. Intangible water quality benefits attributable to the Ironton Park Reservoir would include a more palatable municipal water supply at Ridgway Reservoir by a reduction of the acid mine drainage pollution. Also, the appearance of the river would be enhanced from an aesthetic viewpoint.

PART B - PUBLIC HEALTH ASPECTS

I. SUMMARY AND RECOMMENDATIONS

Summary

1. Project development will improve the economy and permit the establishment of a more healthful environment. Public Health services are provided in the project area by the Colorado State Department of Health.

2. Recreational development contiguous to reservoirs will be partially regulated by the topographical features of the shoreline.

3. Temporary construction camps may be necessary to serve the contractor's employees.

4. As overall watershed management involves many interests, it is essential that the affect on public health be fully coordinated with State and/or local health departments.

5. Mosquitoes are the principal vectors which might be affected by the proposed project, although other insects and rodents may be involved.

6. Encephalitis is the most important mosquito-borne disease in the United States and in the proposed project area. Equine encephalitis cases occurred in Ouray and/or adjoining counties during nine years of the period 1939 through 1955.

7. Extremely prolific production of mosquitoes have been found in meadowlands and roadside ditches in the vicinity of Ridgway.

8. Provision for the prevention and control of man-made vector sources will increase the overall benefits of the project.

Recommendations

Overall watershed management requires the cooperation of many interests to assure that development and activities will minimize the potential public health hazards associated with the proposed project. It is recommended that the following be given due consideration in development of the Dallas Creek Project:

1. That the water users' organization (i. e. Water Conservancy District) operating as the general administrative and contracting agency for the project should:

   a. Alert all water users of the potential public health hazards associated with using inadequately treated water for culinary purposes;

   b. Exert all possible precaution to exclude sewage effluents and barnyard drainage from project canals, laterals, and drains;

   c. Wherever and whenever possible assist the project inhabitants and communities in development of approved water and sewerage facilities;

   d. Operate and maintain project facilities in accordance with established criteria.

2. That potential recreational areas be investigated and at least minimum water and sanitary facilities be provided in accordance with Colorado State Department of Public Health.

3. That a sanitary survey of proposed construction campsites be made and all camps be provided with water and sanitary facilities in accordance with Colorado State Department of Health regulations.

4. That recreational activities at reservoirs utilized as a source of public water supplies meet the requirements established by the Colorado State Department of Health.

5. That person or persons responsible for a public water supply establish suitable controls over the use of watershed areas tributary to the supply to insure production of raw water meeting the quality requirements established by the Colorado State Department of Health.

6. Where applicable, the principles and practices for prevention and control of vector problems associated with reservoirs outlined in Appendix E be adhered to in the design, construction, and maintenance of the project.

7. Where applicable, the principles and practices for prevention and elimination of mosquito sources associated with irrigation outlined in Appendix F be adhered to in the development, operation, and maintenance of the project.

II. PUBLIC HEALTH AND RELATED PROBLEMS

Public Health Services

Project development will improve the economy of the area so that local residents benefiting either directly or indirectly will be in a position to enjoy a higher standard of living. Among other necessities, this involves the establishment of a healthful environment. Some of the more important factors in creating such an environment include the development of safe and ample culinary water supplies, proper waste disposal facilities, and insect and rodent control measures.

Public health services are provided in the project area by the Colorado State Department of Public Health.

Recreational Development

Concomitant with the development of water resources comes the increased use of lands adjoining reservoirs for recreational purposes. This presents major problems of sanitation involving those of coordination of the multiple use policy and prevention of water pollution. The extent of recreational development, planned or spontaneous, immediately contiguous to reservoirs will be partially regulated by the topographical features of the shoreline. Also, a receding shoreline during the irrigation season, together with an accumulation of mud deposits above the water level, will create hazardous and undesirable conditions for some water-based recreational activities.

Construction Phase of Project

Limited housing accommodations are available in the vicinity of construction sites in the Uncompahgre River Basin to serve the contractor's employees during the construction phase of the project. Under these conditions a temporary construction camp may be necessary. Prior to selection of a campsite a sanitary survey of the proposed area should be made by the State Department of Health or the Public Health Service to assist in solving of problems which may be encountered in connection with the installation of water and sanitary facilities.

Water supplies and sanitary facilities required in connection with temporary construction camps and with permanent housing for reservoir attendants should comply with the requirements of the Colorado State Department of Public Health so as to eliminate potential health hazards.

Sanitary Aspects of Watershed Management

As overall watershed management involves many interests, it is considered essential that proposed developments and activities on watersheds pertaining to public health aspects be fully coordinated with State and/or local health departments. These matters should be mutually considered prior to the actual development of the watershed and issuance of permits.

Adequate and safe water and sanitary waste disposal facilities, in accordance with State and/or local health agency standards, should be provided in public use areas to serve camping, picnicking, and other recreational uses. Water and sanitary facilities for private dwelling sites should also meet the established health standards. The effectiveness of the sanitation program should be evaluated periodically by a detailed sanitary survey in conjunction with laboratory analyses of water samples collected from surface and/or ground water in the watershed.

On reservoirs constructed primarily to serve as a source for a municipal water supply, extreme caution should be exercised in considering recreational use of the reservoir. This also involves the possibility of additional pollution entering the water supply and the matter of aesthetics.

Preliminary Vector Evaluation

Anticipated Effects of the Proposed Project on Vector Problems

Mosquitoes are the principal vectors which might be affected by the proposed project, although other insects and rodents may be involved. Several species of mosquitoes of public health importance including Culex tarsalis, the encephalitis mosquito, and the vicious-biting Aedes dorsalis are produced in large numbers in the area when suitable aquatic habitats are present. Basic information concerning pertinent biological characteristics of these mosquitoes is given in Appendix A.

Encephalitis, commonly known as sleeping sickness, or brain fever, is now the most important mosquito-borne disease in the United States and the area in which the proposed project is located. Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in the general project area (Ouray County and/or adjoining counties) during nine years of the 17-year period, 1939 through 1955, for which records are available. Although no outbreaks of encephalitis in humans have been reported from the area of the proposed project, the reported equine encephalitis cases indicate that viruses

of the disease are active in the area. Additional information concerning the public health and socio-economic importance of mosquito and other vector problems associated with water resource developments is presented in Appendix B.

During the field reconnaissances of the project area in June and July 1961, and July 1962, extremely prolific production of mosquitoes was found in meadowlands and roadside ditches in the vicinity of Ridgway. Impoundment of the proposed Ridgway Reservoir would inundate and permanently eliminate these important sources of mosquitoes. Portions of the Ridgway, Sneva, and Dallas Divide Reservoirs that have shorelines with little or no vegetation and are exposed to wave action will be unfavorable for the production of mosquitoes and other aquatic insects of public health importance and will require no special vector prevention or control measures. Mosquito production may occur in tributary embayments and other marginal areas of the reservoirs where the topography is flat and the water is shallow, protected from wave action, and contains emergent vegetation or flotage. Information concerning reservoir preparation, maintenance, and water level management in relation to mosquito prevention and control is presented in Appendix C.

The development of water-related recreational and other public use areas in conjunction with the proposed reservoirs may result in the exposure to humans to vectors of terrestrial origin, including arthropods such as ticks, fleas, and flies, and rodents such as ground squirrels, chipmunks, and mice. In order to minimize public health hazards at waterside recreational areas, appropriate prevention and control measures for both aquatic and terrestrial vectors should be carried out.

Observations during the field surveys of the project area showed numerous existing mosquito sources in the presently irrigated sections resulting from inadequate drainage facilities and seeped or waterlogged lands in the valley areas. It is anticipated, therefore, that provision of a larger supply of water for lands presently irrigated and the development of additional new irrigated areas may aggravate existing mosquito sources and create new aquatic habitats favorable for mosquito production unless appropriate prevention and control measures are provided and continued as a part of the regular operation and maintenance. Pertinent information concerning the relationships between irrigation and mosquito sources is presented in Appendix D.

By making provisions for the prevention and control of man-made vector sources, the overall benefits of the project can be greatly increased.

Responsibility for Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. Therefore, the agency, group, or individuals responsible for various aspects of the proposed project should be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the project.

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APPENDIX A

Biology of Mosquitoes

This discussion is intended to provide only basic information concerning some of the more pertinent biological characteristics of mosquitoes commonly associated with water resource developments. These mosquitoes represent four important genera or groups: Anopheles, Culex, Aedes, and Psorophora. All mosquito species have four distinct stages in their life cycle: the egg, the larva ("wiggler"), the pupa ("tumbler"), and the adult. A characteristic common to all mosquitoes is that they live in water continuously from the time the eggs hatch until the adults emerge. The aquatic stages generally occur in shallow water with an abundance of vegetation and flotage, and where they are protected from wave action. They do not occur in the deep open waters of lakes, ponds, or streams.

On the basis of egg-laying habits, mosquitoes may be divided into temporary-water and permanent-water species. The Aedes and Psorophora are temporary water breeders which deposit their eggs on the moist soil of areas where surface water has receded. Hatching of the eggs is stimulated by subsequent floodings. The eggs may remain dormant for long periods, sometimes for several years if conditions are unfavorable for hatching. Normally, the eggs hatch more or less simultaneously soon after they are flooded. In contrast, the Anopheles and Culex usually lay their eggs on the surface of permanent and semipermanent bodies of water. The eggs usually hatch within a few days after oviposition. For both the temporary-water and permanent-water mosquitoes, time between hatching of eggs and emergence of adults varies with species and environmental conditions, especially water temperature. Development of the aquatic stages may be completed in as little as four days in hot weather while several weeks may be required in cool weather. Aedes and Psorophora mosquitoes generally develop more rapidly than the Anopheles and Culex.

Adult mosquitoes mate soon after emergence and the females begin seeking blood meals, which most species require before laying eggs. The biting habits of adult mosquitoes vary with species. Anopheles and Culex mosquitoes feed mainly at night while Aedes and Psorophora species feed both at night and in the daytime. Most species exhibit a peak of biting activity during a one or two-hour period immediately after sundown. The Aedes and Psorophora species are aggressive and vicious biters of both man and livestock. Culex tarsalis, a vector of encephalitis, feeds readily on a wide range of hosts including man, wild and domestic birds, and livestock.

The flight range of mosquitoes varies widely with species and environmental conditions. The direction and distance of travel are greatly influenced by availability of food, shelter, and wind conditions. Availability of food is probably the most important factor influencing the movement of mosquitoes in many areas. If an adequate food supply is close to the production sites, adult mosquitoes probably will not travel far from their sources. On the other hand, mosquitoes may travel several miles when adequate food supplies are not available nearer their larval habitats. The normal flight range of the Anopheles and Culex mosquitoes is usually considered to be about one mile, although recent studies have shown that certain species such as C. tarsalis may travel several miles under certain environmental conditions. Most Aedes and Psorophora species are strong fliers and are known to range several miles from their larval habitats.

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APPENDIX B

Public Health and Socio-Economic Importance of Vector Problems Associated with Water Resource Developments

Several groups of arthropods and rodents associated with the development and utilization of water resources may create serious public health and socio-economic problems. These include species that are vectors of disease organisms or serve as reservoirs of these organisms or which otherwise interfere with man's health and welfare.

Mosquitoes

Approximately a dozen species of mosquitoes of public health and socio-economic importance may be produced in habitats associated with irrigation, impoundments, and other water resource developments. Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States. Mosquitoes obtain the encephalitis viruses from wild vertebrates and then transmit them to horses and humans. There are no effective chemotherapeutic measures for preventing or treating human cases; and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability. Three principal types of mosquito-borne encephalitis occur in the United States. Eastern encephalitis (EE) occurs mainly in the Atlantic and Gulf Coast States from New Hampshire to Texas, but sometimes extends as far inland as Wisconsin. St. Louis encephalitis (SLE) occurs chiefly west of the Mississippi River and in several of the Central States. The third type, western encephalitis (WE), is confined primarily to the states west of the Mississippi River.

Culiseta melanura and several species of Aedes mosquitoes are believed to be involved in the transmission of EE. The principal vector of both WE and SLE in the Far West is Culex tarsalis, a mosquito which is widely distributed west of the Mississippi River. In the Central States, Culex pipiens and Culex quinquefasciatus are believed to be important in the transmission of SLE. Aedes and other mosquitoes may also be involved as secondary vectors of encephalitis. Both western and St. Louis encephalitis are endemic in many western areas, and outbreaks of WE among horses and of WE and SLE among humans have been rather widespread. In recent years, outbreaks of encephalitis have occurred in irrigated areas in the Texas High Plains (1956), in the Intermountain States (1957), in the Lower Rio Grande Valley (1957), in Utah and New Mexico (1958), and in Wyoming (1960).

The occurrence of malaria outbreaks as a result of improperly prepared reservoirs in the southeastern States is well documented. Malaria has also been associated with irrigation in several States including California, New Mexico, Texas, and in the rice-growing areas of the Mississippi Delta. This disease has been almost eradicated from the United States; and at present, there is no significant malaria transmission anywhere in the Nation. The malaria vectors (Anopheles quadrimaculatus in the East and Anopheles freeborni in the West) are still prevalent in some areas where favorable habitats are present. These mosquitoes constitute a potential hazard for the establishment of new foci of malaria transmission, particularly in situations where the disease may be reintroduced from foreign countries. This was well illustrated at Lake Vera in California during the summer of 1952, where 35 cases of malaria occurred among Camp Fire Girls. The source of their infections was traced to a soldier who had an attack of malaria while camping at the lake.

Several vicious-biting species including Aedes vexans, Aedes dorsalis, and Aedes nigromaculis may be produced in habitats associated with irrigation and other water resource projects. These mosquitoes often create public health problems aside from the transmission of specific diseases. Such health hazards are illustrated by the results of surveys made by the U.S. Public Health Service in irrigated areas in northern Montana. In three-fourths of the families surveyed, mosquitoes severely annoyed both adults and children and interfered with their normal outdoor activities during the summer months. Mosquito bites caused some degree of injurious reaction in 8 out of 10 people interviewed; and in one section, 40% of the individuals examined by the physician showed evidence of secondary infection of mosquito bites. Some individuals, particularly children, frequently required medical attention and sometimes even hospitalization for treatment of secondary infections and occasional allergic reactions caused by mosquito bites.

In addition to their public health importance, mosquitoes often create other serious problems in both rural and urban areas. Their vicious biting reduces the efficiency of farm workers and sometimes hinders the harvesting of crops. Dense populations of attacking mosquitoes have been reported to kill livestock. The constant attacks of even moderate populations of these insects may reduce the vitality of farm animals and prevent proper feeding, thereby causing reduced weight gains and lower milk and egg production. Mosquitoes are vectors of encephalitis, anaplasmosis, fowl pox, and several other important diseases of animals. These diseases kill large numbers of farm animals each year. Together, mosquito annoyance and mosquito-transmitted diseases undoubtedly result in losses of millions of dollars to farmers every year.

Large numbers of biting mosquitoes also cause serious economic losses by reducing the efficiency of industrial workers, lessening the value of real estate, restricting outdoor recreational activities, and reducing attendance at outdoor business establishments such as drive-in theatres and eating places.

The economic magnitude of the irrigation-mosquito problem alone is illustrated by expenditures for abatement of these insects. For example, in California over $5,000,000 is spent annually to control encephalitis and other irrigation mosquitoes and it has been estimated that at least twice this amount would be required to provide adequate control throughout the State. Approximately $200,000 is spent each year for mosquito abatement in a few irrigated areas in Utah. Many urban communities in other western irrigated areas spend large sums of money each season for chemical control to provide partial protection from mosquitoes. Individual families also spend sizable amounts of money each summer for household sprays, mosquito repellents, livestock sprays, and medicine for treatment of mosquito bites. The total cost of controlling irrigation mosquitoes, together with the other serious economic losses they cause, runs into many millions of dollars each year. Thus, mosquitoes are a major economic liability in many irrigated areas.

Other Aquatic Insects

Several other groups of aquatic insects may be produced in sufficient numbers in habitats associated with water resource projects to create public health and economic problems. Deer flies and horse flies (Tabanidae) are produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Some species of small gnats of the family Heleidae are also vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp areas of many irrigated valleys as well as salt marshes and other wetland areas. In certain areas, black flies (Simuliidae) plague both man and livestock with their irritating and painful bites. They are normally produced in streams but sometimes occur in large numbers in irrigation conveyance systems. The small nonbiting midges (Tendipedidae) and the phantom midges (Chaoborinae) are another group of pestiferous insects which may be produced in impounded water. These insects are attracted to lights in tremendous numbers and cause severe human annoyance. An example is the Clear Lake gnat, Chaoborus asticopus, which creates serious problems at the resort areas in Lake County, California.

Terrestrial Arthropods and Rodents

Each summer, many millions of people visit picnic sites, campgrounds, cabins, and other water-related recreational facilities along the shores of reservoirs. In addition to mosquitoes and other insects of aquatic origin, these people are often exposed to terrestrial arthropods such as ticks, mites, fleas, and flies and rodents including ground squirrels, rats, mice, and chipmunks. The public health importance of these arthropods and rodents involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, tularemia, relapsing fever, tick paralysis, typhus, plague bacillary dysentery, and typhoid. The bites of certain arthropods also cause considerable irritation, discomfort, and annoyance.

APPENDIX C

Reservoir Preparation, Maintenance, and Water Level Management in Relation to Mosquito Prevention and Control

Man-made impoundments range in size from large multipurpose reservoirs with thousands of acres to small farm ponds of less than an acre. Mosquito-producing conditions associated with both large and small impoundments are basically similar but vary greatly in magnitude. They include emergent vegetation and/or floating debris in shallow water areas which are protected from wave action; undrained depressions, borrow pits, sloughs, and marshes within the summer fluctuation zone; and rising or constant pool levels which cause the water to remain in relatively flat areas with vegetation for more than four or five consecutive days during the mosquito production season. Several species of Anopheles and Culex mosquitoes, including Culex tarsalis, are frequently produced in impoundments that have protected shallow water areas with emergent vegetation and/or flotage. The flat vegetated areas of reservoirs and ponds, which are alternately inundated and exposed by fluctuating water levels, may also be highly favorable for the production of several species of Aedes and Psorophora mosquitoes. Aedes vexans is one of the most common and widespread of these species. It is almost axiomatic that reservoirs and ponds which are free of vegetation and flotage do not produce mosquitoes.

It is often difficult to control mosquito production on a reservoir that has not been properly prepared prior to impoundage. Clearing and drainage are the principal reservoir preparation measures for mosquito prevention and control. The overall objective of these measures is to prevent or minimize the development of favorable mosquito-producing habitats in any portion of the reservoir which is within flight range of human population.

Clearing includes removal of trees, underbrush, vines, fences, and debris from the reservoir basin. For mosquito control purposes, the normal summer fluctuation zone should be completely cleared except for isolated trees and sparse vegetation located along abrupt shorelines that will be exposed to wave action. It is not necessary to clear timber from the deeper portions of the reservoir basin where it will be completely submerged at normal summer minimum pool elevation. Timber rooted below the normal summer minimum pool level but extending above that elevation may be felled and securely tied down in lieu of disposal. This practice sometimes has advantages in fisheries management. Where clearing operations extend over several seasons, it is sometimes necessary to remove regrowth from the normal summer fluctuation zone immediately prior to impoundage.

Borrow pits, depressions, marshes, and sloughs which will be flooded when the reservoir is at maximum pool level and which will retain water at lower pool levels may be serious mosquito sources. Drainage ditches should be provided for all such areas, particularly those located within the normal summer fluctuation zone. These ditches should insure complete drainage of the areas when the reservoir recedes and permit fluctuation of water levels in them when the reservoir is at higher elevation. Such drainage ditches may also serve to prevent the stranding of fish when the lake recedes. Logs, drift, and other debris should be removed from natural drainageways and existing ditches where such work is indicated for mosquito prevention and control. Permanent shoreline improvement measures can sometimes be employed to eliminate mosquito-producing areas in reservoirs when the normal summer fluctuation zone is limited to a few feet.

Since the effectiveness of naturalistic, preventive, and permanent mosquito control measures is determined by the amount of clean water surface they create, it is essential that ponds and reservoirs be properly maintained after they have been impounded. Furthermore, maximum mosquito control benefits from water level management can be realized only when impoundments are properly prepared and maintained. Several phases of water level control, such as flood surcharge, constant level pool, cyclical fluctuation, and/or seasonal recession, can sometimes be adapted to various types of impoundments in order to minimize conditions favorable for mosquito production. Certain phases may be used to control vegetation and flotage or they may be used primarily to destroy mosquito larvae. A flood surcharge above the normal pool level for a few days in the spring prior to the mosquito production season followed by a sharp drawdown is effective in stranding objectionable flotage. The invasion of marginal vegetation can be limited by holding the reservoir at a constant level during the early spring growth period. This phase is especially important since it increases the effectiveness of subsequent fluctuation and/or recession. Seasonal water level recession alone or in combination with periodic fluctuation is an effective control measure since it provides a clean shoreline which is unfavorable for mosquito production. In some irrigation storage reservoirs, the normal water releases during the growing season usually result in a drawdown that keeps the pool level below encroaching marginal vegetation, thereby providing a clean shoreline that is unfavorable for mosquito production.

Recreational areas, especially those with facilities where people may remain overnight, should be located along sections of the reservoir which have the lowest potential for the production of mosquitoes and other aquatic insects of public health importance.

Proper consideration should also be given to terrestrial vector problems in selecting recreational sites. Where necessary, full provision should be made for the prevention and control of both types of vector problems.

APPENDIX D

Relationships Between Irrigation and Mosquito Sources

The production of mosquitoes and other aquatic insects of public health importance occurs in many western irrigation areas, particularly where the water is applied by surface methods. Natural mosquito habitats are present in most irrigated areas, but usually man-made mosquito sources are far more important. These man-made aquatic habitats are frequently caused by the same faulty irrigation and drainage practices that result in serious soil and water problems such as excessive water losses, waterlogging, erosion, salt and alkali accumulations, damage to soil structure, leaching of plant nutrients, and reduced crop yields. Some of the "on-field" and "off-field" mosquito sources commonly associated with irrigation in the west are briefly discussed in the following sections.

On-Field Mosquito Sources

Prolific mosquito production occurs in low areas on fields used for pastures, hay meadows, and other close-growing forage crops where irrigation water often remains ponded long enough for the larvae to mature. Mosquitoes are sometimes produced on fields planted to irrigated row crops such as cotton, but usually ponded water is not present on these fields long enough for the aquatic stages to complete their development. Surface water must be present for at least four or five days in order for the aquatic stages to mature and produce adult mosquitoes. Rice is the only field crop that thrives when flooded this long. Observations in several areas have shown that when irrigation water is ponded on pastures and hay meadows long enough to produce mosquitoes, the desirable forage grasses and legumes are frequently killed and replaced by undesirable wetland plants. Thus, the extended flooding which is conducive to mosquito production is unfavorable for satisfactory growth of the common field crops.

In California, tremendous numbers of Aedes nigromaculis are produced in the ponded areas on irrigated pastures. Some of these pastures are irrigated 10 to 15 times from April through October and a brood of mosquitoes may be produced in the ponded water that remains after each irrigation. Investigations in the Milk River Valley of northern Montana showed that over two-thirds of all mosquito production (mostly Aedes dorsalis and A. vexans) on a 5,000-acre study area occurred in ponded areas on irrigated alfalfa fields, pastures, and western wheat grass meadows. In this valley, the irrigation water frequently remains ponded on the hay meadows long enough to produce Culex tarsalis, the encephalitis mosquito. Studies in Nebraska

showed that large numbers of both C. tarsalis and Aedes mosquitoes are produced in ponded areas on irrigated pastures and hay meadows along the North Platte River. The use of irrigated mountain meadows for the production of hay and supplemental grazing of livestock is widespread in the Rocky Mountain States. In many of the mountain valleys, the bottomland meadows are flooded almost continuously throughout the spring and early summer months. Ponding also occurs in numerous low areas following irrigation later in the season. The extensive aquatic habitats that occur on many irrigated mountain meadows produce tremendous numbers of encephalitis and other irrigation mosquitoes.

In addition to the depressions on irrigated fields, water sometimes remains ponded in the field laterals and drains long enough to produce encephalitis and other irrigation mosquitoes. This type of mosquito source occurs most often in areas having fine textured soils and poor underdrainage. Field laterals and drains that contain excessive amounts of vegetation are more favorable for mosquito production. Mosquitoes may also be produced in the residual water in various hydraulic structures, such as drops in ditches, particularly when they contain tumbleweeds and other debris. Mosquito production in hydraulic structures is usually of minor importance in comparison with that which occurs in other types of "on-field" aquatic habitats.

Rice fields constitute a special type of "on-field" mosquito source, since the flooding used for growing rice is very favorable for mosquito production. In rice fields of the Mississippi Delta and Gulf Coast areas, large numbers of Psorophora confinnis and Psorophora discolor are produced by intermittent irrigation; and Anopheles quadrimaculatus, the malaria mosquito, is produced in the constantly flooded rice fields. Rice fields in California are usually flooded throughout the growing season and they provide favorable aquatic habitats for production of Culex tarsalis, the encephalitis mosquito, and Anopheles freeborni, the western malaria mosquito. Large numbers of A. nigromaculis and A . dorsalis mosquitoes are frequently produced by the initial flooding of rice fields in California.

Off-Field Mosquito Sources

In many western irrigated areas, widespread and prolific mosquito production occurs in a variety of aquatic habitats located outside the boundaries of irrigated fields. These mosquito sources include roadside ditches, borrow pits, depressions on nonirrigable land, and numerous other undrained areas that are flooded by surface runoff from irrigated fields and other excess irrigation water. Such aquatic habitats often contain dense vegetation which makes them more favorable for mosquito production. The semipermanent and permanent water areas are highly favorable for C. tarsalis, the encephalitis mosquito. Those with fluctuating water levels produce large numbers of this mosquito as well as several vicious-biting Aedes species.

The types of "off-field" habitats just described accounted for more than one-fourth of the total mosquito production on a 5,000-acre study area in the Milk River Valley of northern Montana. In the North Platte Valley of western Nebraska, wasteland areas, roadside ditches, borrow pits and other undrained areas flooded by runoff from irrigated fields and overflow from conveyance systems were found to be important sources of both C. tarsalis and Aedes mosquitoes. Playas or land-locked depressions, flooded by runoff from irrigated fields, were responsible for three-fourths of all mosquito production on study areas in the Texas High Plains. These playas produced large numbers of C. tarsalis and several other species of irrigation mosquitoes. In certain western areas, large nonirrigable areas are wildly flooded with excess irrigation water for use by ducks and other waterfowl. Such areas are highly favorable for the production of tremendous numbers of Aedes mosquitoes. Several of the abatement districts in California and Utah spend large sums each year to control mosquitoes produced on waterfowl areas of this type.

Mosquito sources are often associated with the main irrigation conveyance systems, portions of which are sometimes located on nonirrigable lands. A large amount of irrigation water is often lost by seepage and leakage through the beds and banks of unlined canals and laterals which are located in pervious material. In areas having poor underdrainage, these seepage losses alone or in combination with deep percolation from irrigated fields often result in marshes and ponded water in roadside ditches, borrow pits, and other areas. In many western irrigated areas, aquatic habitats created by seepage produce large numbers of mosquitoes. Permanent and semipermanent seepage areas have been found to be especially favorable for the production of C. tarsalis, a vector of encephalitis. Large numbers of Aedes mosquitoes are also produced in seepage areas that have fluctuating water levels.

Mosquito production may also occur in various other "off-field" aquatic habitats associated with the main irrigation conveyance systems. These mosquito sources include flooded areas resulting from overflow of poorly maintained canals and laterals; ponded areas where conveyance channels block natural drainageways; residual water in turnouts, stilling basins, and other hydraulic structures; surface pools created by leakage from water control structures; and residual water in conveyance channels during nonoperational periods. Although these types of aquatic habitat contribute to the total mosquito problem, they are generally of less importance than those caused by seepage and the numerous other "off-field" mosquito sources.

APPENDIX E

Principles and Practices for Prevention and Control of Vector Problems Associated with Reservoirs

I. Prevention and Source Reduction Measures

A. For Mosquitoes and Other Aquatic Insects

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. Prior to impoundage, the reservoir basins should be prepared as follows:

   a. The normal summer fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines which will be exposed to wave action.

   b. Dense stands of timber rooted below the normal summer minimum pool level but extending above that elevation should be cleared. In some situations, such timber may be felled and securely tied down in lieu of disposal.

   c. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

   d. If the summer fluctuation zone of the permanent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas located within flight range of population groups or recreational areas through the use of measures such as deepening and/or filling. This would minimize the need for repetitive measures for controlling vegetation and mosquito production.

3. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

   a. All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.

   b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

4. Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoir. This will minimize the need for repetitive measures for controlling vegetation and mosquito production.

5. As a general principle, waterside recreational areas, particularly those which have facilities for overnight human occupancy, should be located along sections of the reservoir which have a low production potential for mosquitoes and other aquatic insects of public health importance.

B. <u>For Terrestrial Arthropods and Rodents at Recreational Areas</u>

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish, and other materials which may serve as harborage for rodents and other small mammals should be removed periodically.

4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infestation.

II. Supplemental Chemical Control Measures

In situations where adequate vector control is not obtained through prevention and source reduction measures, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control.

III. Vector Appraisal

Arrangements should be made for carrying out a routine program of vector appraisal as a part of normal operations of the reservoir and associated recreational areas. Inspections for adult and larval mosquitoes and other vectors are essential for planning and evaluating control measures and for adjusting control programs to meet temporary or emergency situations.

APPENDIX F

Principles and Practices for Prevention and Elimination of Mosquito Sources Associated with Irrigation

A. Project Conveyance and Distribution Systems

1. Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous material where excessive leakage would result in waterlogged areas, seeps, and ponds.

2. Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to avoid ponding.

3. Borrow areas should be self-draining to keep them from retaining ponded water.

4. Where possible, provision should be made to prevent turnouts and other hydraulic structures from retaining residual water when they are not being used.

5. Effective measures should be provided to prevent ponding of leakage from water control structures.

6. Every effort should be made to establish delivery schedules which will provide farmers with adequate but not excessive amounts of water at proper intervals to insure efficient irrigation of the crops concerned.

7. Vegetation and debris which would retard normal flows should be periodically removed from conveyance channels, water control structures, and drains.

B. Project Drainage Systems

1. Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and nonirrigable lands affected by the distribution and use of irrigation water on the project.

2. Drainage ditches should be designed, constructed, and maintained so as to minimize ponding in the channels and to insure free flows at all times.

3. Provision should be made to prevent water from ponding behind spoil banks.

4. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

C. Irrigated Farms

1. The sponsoring agency and other organizations concerned with irrigation agriculture or mosquito control should do everything possible to encourage irrigation farmers to use the following irrigation and drainage practices which will prevent or minimize mosquito sources:

   a. The farm supply system, drainage system, and field layouts should be properly fitted to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

   b. All surface irrigated fields should be properly leveled or graded to provide for efficient water application and removal of excess water without ponding.

   c. An adequate drainage system should be provided for removal of excess water from all portions of the farm.

   d. Irrigation methods should be used which will provide optimum irrigation efficiencies.

   e. Application of irrigation water should be limited to that required to fill the crop root zone plus unavoidable losses and excess water needed to prevent upward movement of salts.

APPENDIX G

Principles and Practices for Prevention and Elimination of Mosquito Sources Associated with Irrigation

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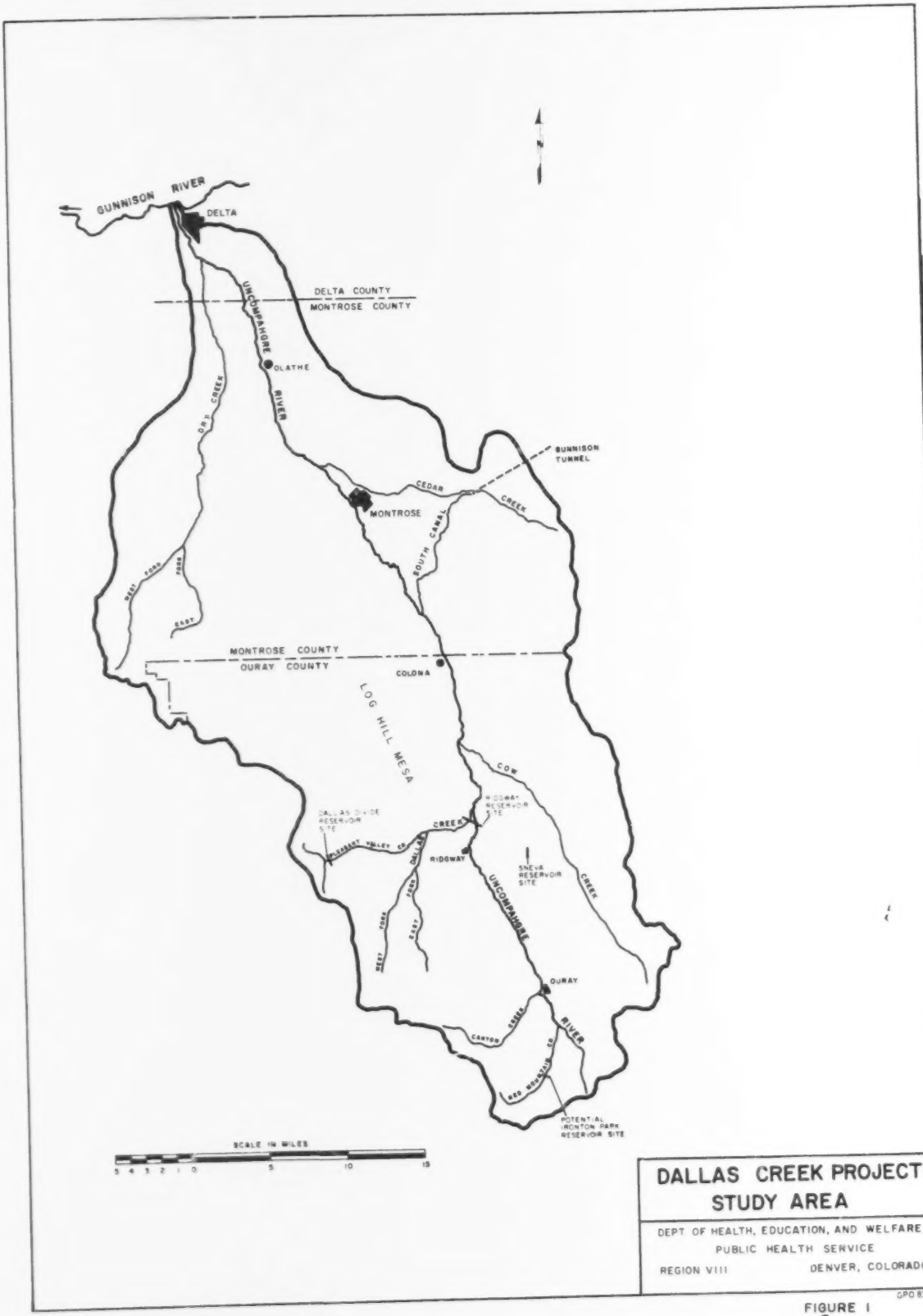
GPO 837-743



DALLAS CREEK PROJECT STUDY AREA

DEPT. OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

GPO 834753

FIGURE 1
C-3